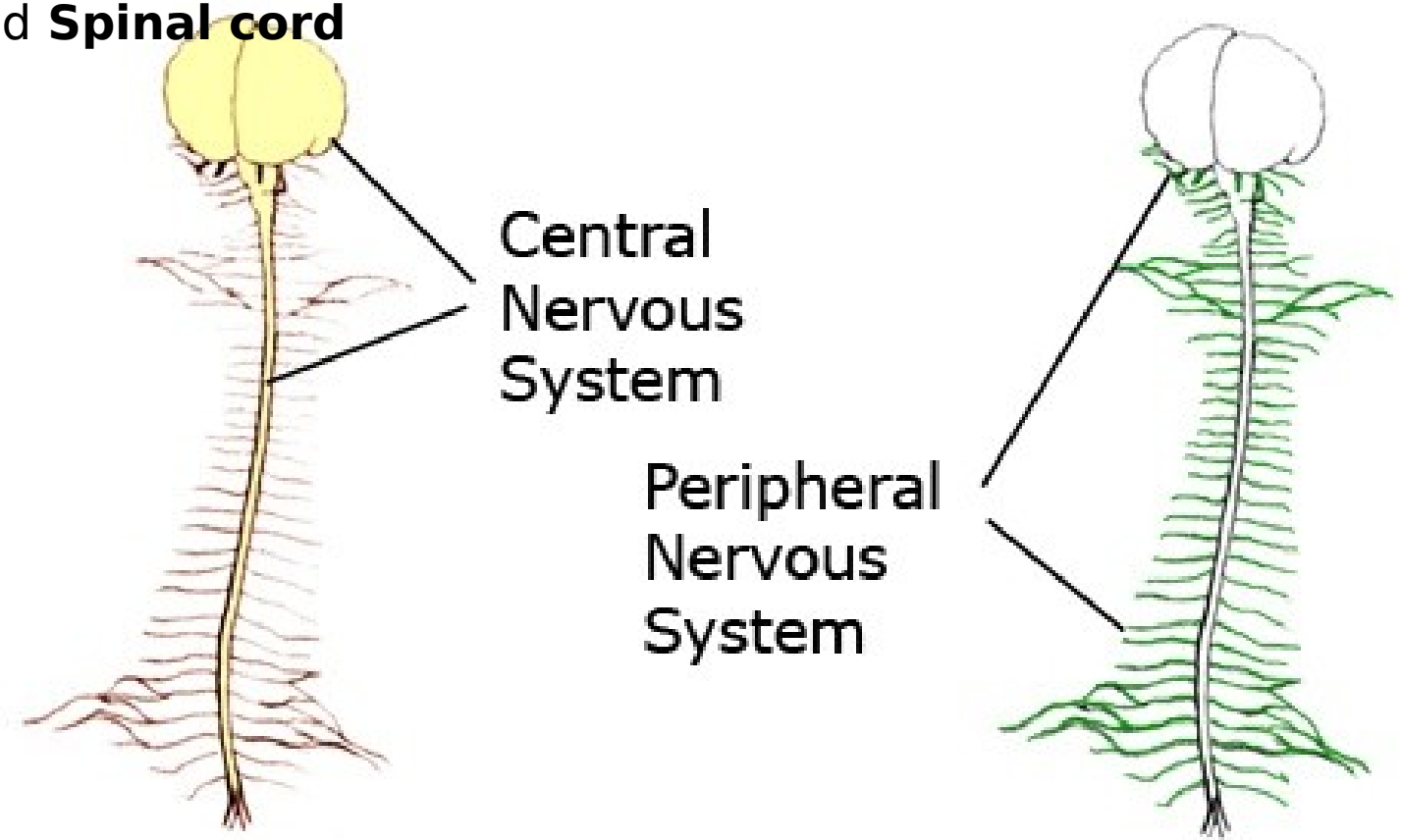
The Nervous System

The Central Nervous System (CNS) is composed of the **Brain** and **Spinal cord**



Spotlight on the Peripheral Nervous

The Peripheral Nervous System (PNS) is composed of **Ganglia and Nerves**

Central Nervous System

Peripheral Nervous System

The PNS has 2 components:
The SNS and the ANS

Somatic Nervous System (SNS)

Voluntary*

Effector Tissue is:

Skeletal Muscle Only!

Autonomic Nervous System (ANS)

(has 2 divisions)

Involuntary#

(2 divisions)

Parasympathetic

Sympathetic

Effector Tissues are:

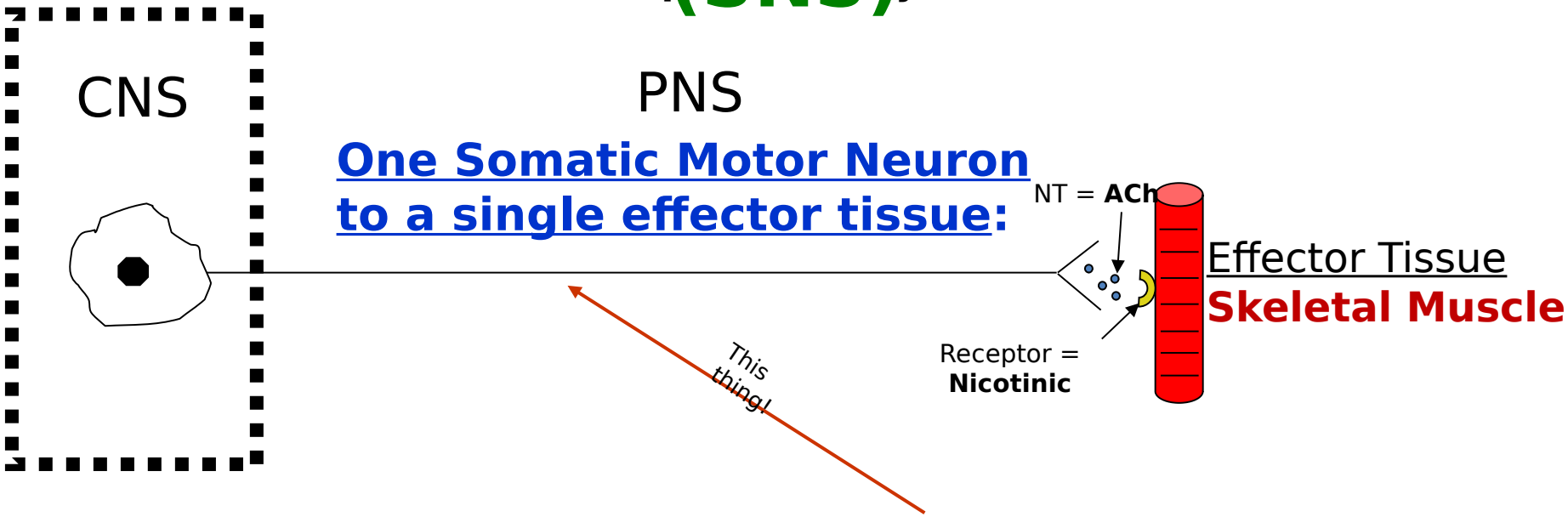
1. **Cardiac Muscle**

***Except for Reflexes**

#Except for Biofeedback mechanisms

The Somatic Nervous System (SNS)

This one is simple and easy – so let it be!



happens is that a Somatic Motor Neuron
uscle fibers and then the muscle contrac

If they do not send a signal, the muscle stays relaxed!

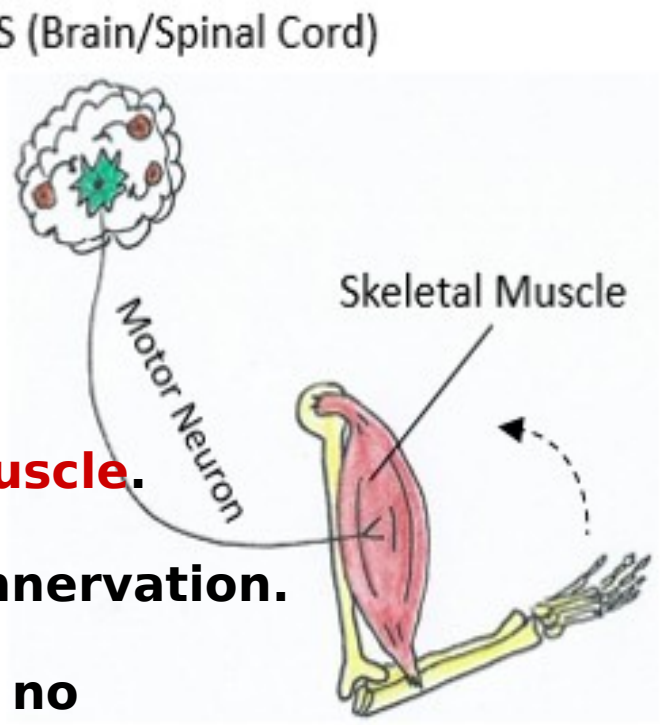
e.g., the musculocutaneous nerve sends a signal and presto, the biceps brachii contract!

Easy, huh?

Summary Notes on SNS:

The **Somatic Nervous System** (SNS) is simple anatomically.

s mostly under Voluntary control, meaning
are consciously aware of body movements.
(The *exception* is reflex actions)



ere are the important concepts of SNS:

There is only 1 Somatic Motor Neuron.

acts on 1 Effector Tissue only = Skeletal muscle.

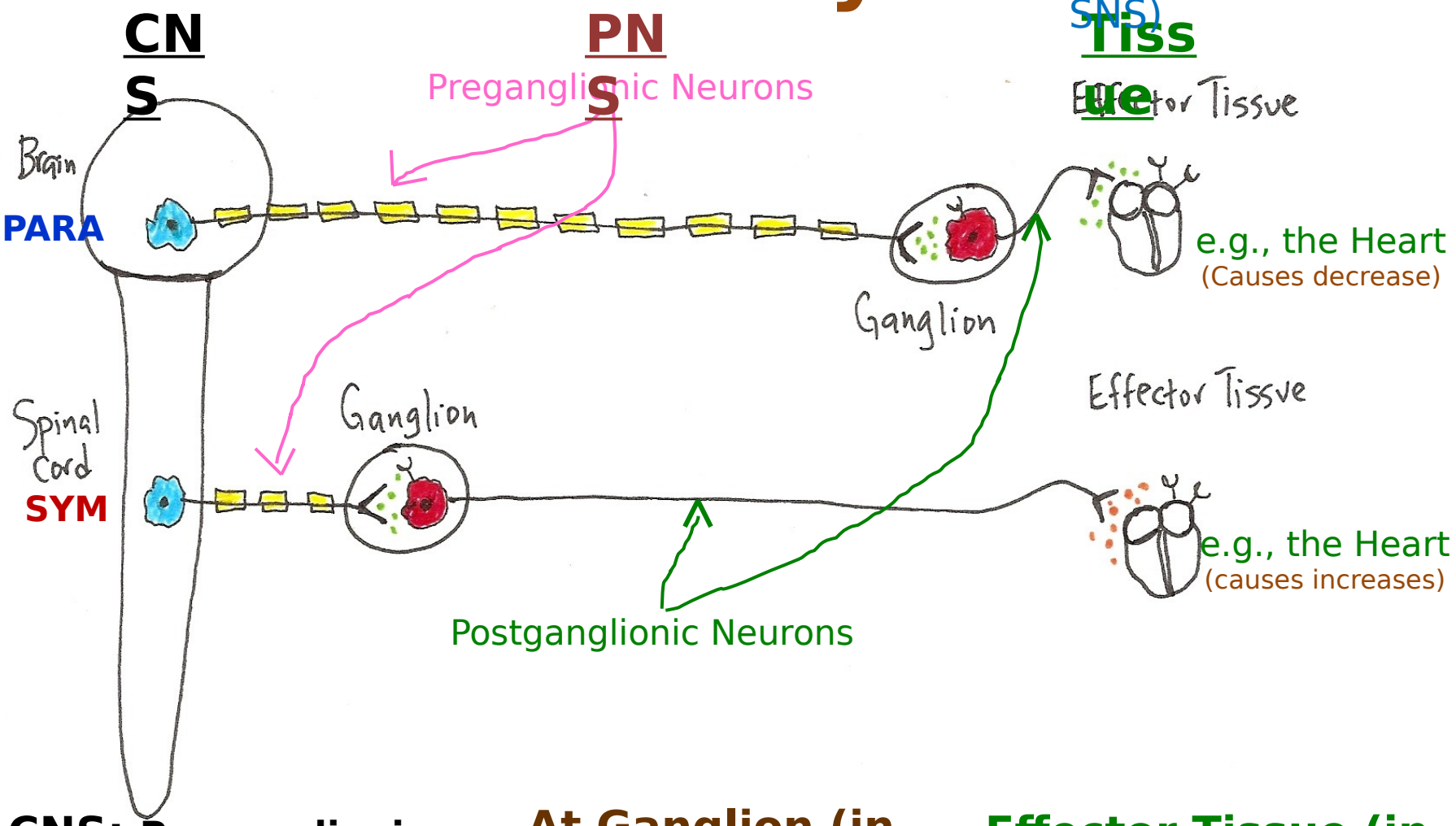
eletal muscle contracts as a result of this innervation.

- **Skeletal muscle relaxes when there is no signal from somatic motor neurons.**

We will **not** go into details about neurotransmitters and receptors, but…
At the neuromuscular junction for skeletal muscle, **somatic motor neurons** release **ACh** (acetylcholine) onto **nicotinic** receptors.

tonomic Nervous System

(the ANS is **more complex** than the SNS)



In CNS: Preganglionic Neurons

Para = Craniosacral Origin*

Sym = Thoracolumbar Origin*

*The term 'origin' means where in the CNS do these first ANS neurons come from

At Ganglion (in PNS):

Postganglionic Nerve cell bodies

Note that the same actions occur at the ganglion for both divisions, they are identical.

Effector Tissue (in PNS):

Cardiac Muscle

Smooth Muscle

Glands

Here at the effector tissue is where the 2 divisions (Para and Sym) of the ANS differ

ANS Overview Notes:

The Autonomic Nervous System (ANS) is complex.

It has 2 divisions: The **Para**sympathetic and the **Sym**pathetic. There are **3** basic effector tissues in the ANS for both divisions: ♡ cardiac muscle, ▯ smooth muscle, and ▯ glandular tissue. **Both** divisions have the ***same effector tissues***, but often the 2 divisions have ***antagonistic*** (opposing) effects.

The catch phrase for **Para** is: "Rest and Digest". For **Sym** it's: "Fight or Flight". Keep those terms in mind as they help reveal what the actions are on effector tissue.

The ANS involves **2 motor** (efferent) **neurons** in sequence. The **1st** neuron is from the CNS to a ganglion (it's called the ***preganglionic*** neuron) and the **2nd** neuron is from the ganglion to the effector tissue (it's called the ***postganglionic*** neuron).

- A **ganglion** is a cluster of nerve cell bodies in the PNS. Right? :)
- A **nerve fiber** is a single axon. Right? :)

In the detailed drawings, please notice how the ***ganglia*** in the **Para** division are close to the effector tissue, but in the **Sym** division they are close to the CNS. Also, notice the nerve fibers (axons) for the preganglionic neurons in the Para are *very long* and the nerve fibers for the postganglionic are *very short*. It is the **opposite** arrangement for the Sym division! What do you notice about axon myelination?

Summary Notes on ANS:

The **Autonomic Nervous System** (ANS) is more complex anatomically.

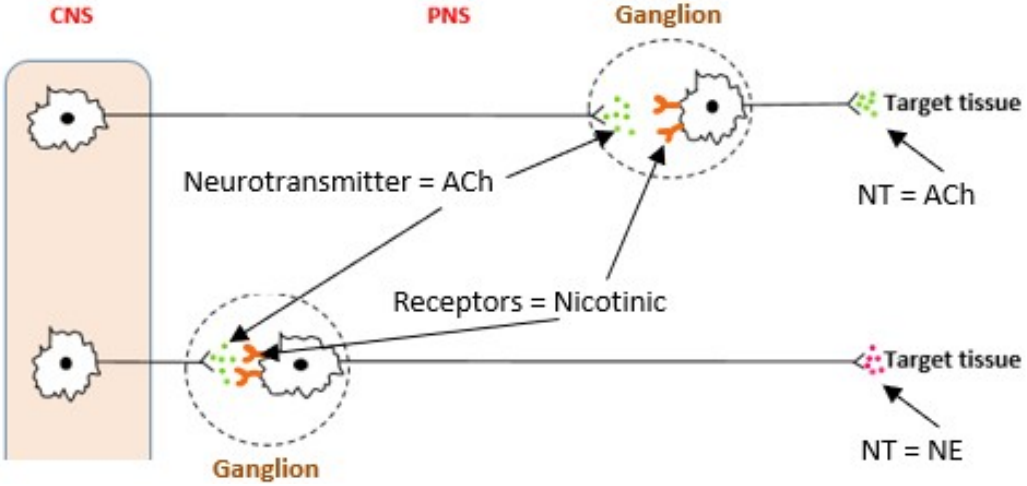
ANS is mostly under Involuntary control, meaning are not consciously aware of these responses.

(The *exception* is **biofeedback** actions)

e are the important concepts o

ere are 2 Motor Neurons in the

- The **preganglionic** neuron
- The **postganglionic** neuron



s on 3 Effector Tissues:

Cardia muscle – of the heart.

Smooth muscle – of blood vessel walls, bronchioles, ducts, tracts and organs.

Glands – of exocrine (sweat, salivary, etc.) and endocrine (hormones, etc.) gla

There are **2 divisions** of the ANS, the **Parasympathetic** and the **Sympathetic**

For the most part they oppose each other: Para is for resting and digesting, and Sym is for fast emergency responses to prepare the body for danger or excitement.

More ANS Notes:

In general, **Para** is for 'housekeeping' activities ("**Rest & Digest**"), storing needed things, relaxing, getting rid of things and doing some chores!

e.g., after lunch, as you decide to sit and read - **Para** is at work! Heart rate is low, saliva and G.I. tract activity are high, bronchiole (airways) diameter is small, no need for much air, everything is fine, there's no hurry, you've got all day. Pupil diameter is small too, enabling that *near focus* to get all the fine details!

In general, **Sym** is for emergency situations ("**Fight or Flight**")! You may have to fight or run – either way it takes a lot of energy.

e.g., imagine as you sit down to read, a big scary bug enters the room. Presto - immediately the **Sym** is at work. Heart rate skyrockets (to get more blood to body, and get you out of danger), your G.I. activity comes to a halt, and bronchioles diameter gets larger, as you need more air flow to either fight or run. More Sweat? Yes. Dry mouth? Yes. Pupil diameter becomes larger too, enabling *distant focus* so you can see an escape route! You are ready!!!

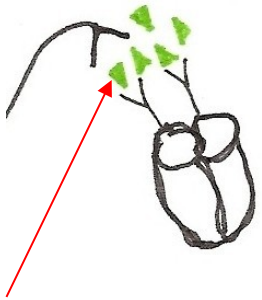
Note: The NT released (**ACh**) and receptors at the ganglion (**Nicotinic**) are the same in both divisions!

They are different at the Effector Tissue, where the Para releases ACh and the Sym releases NE

PARA

Now let's compare how the 2 –'s of the ANS Effect the Heart

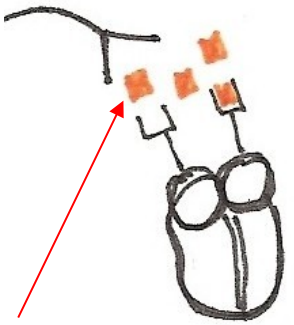
SYM



The **neurotransmitter** acetylcholine (**ACh**) is released from Postganglionic **Parasympathetic** neurons, that is, at the effector tissue!

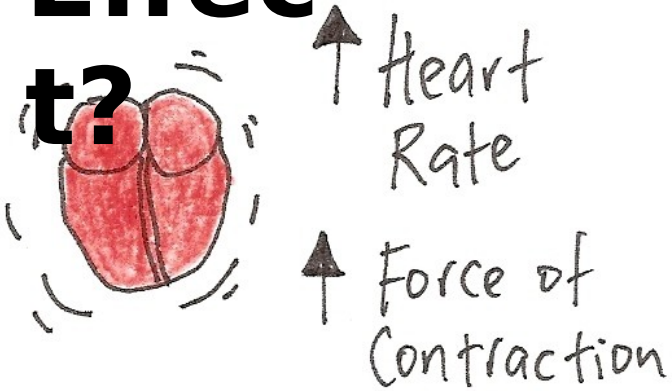
Effect?

PARA = "Rest and Digest"



The **neurotransmitter** norepinephrine (**NE**) is released from Postganglionic **Sympathetic** neurons, that is, at the effector tissue!

Effect?



SYM = "Fight or

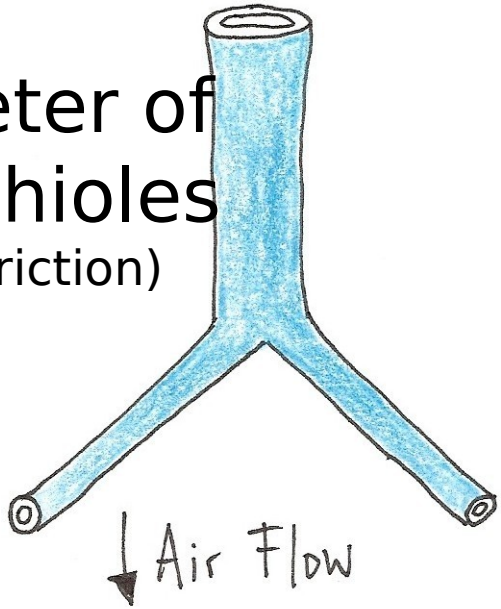
PARA

SYM

The Lungs? (Bronchioles)

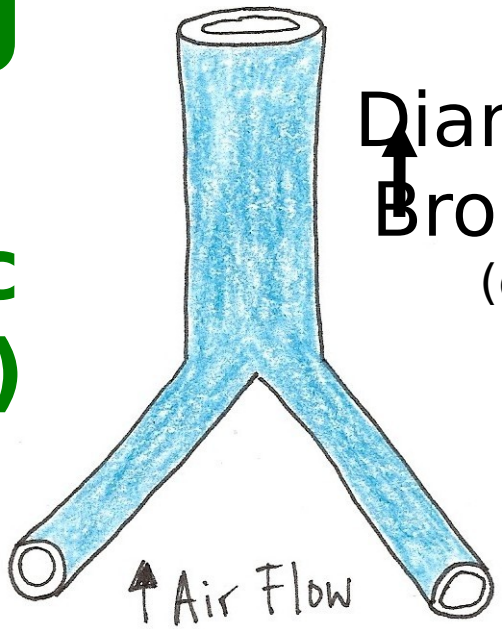
Bronchioles are tiny tubes in the lungs that air flows through

Diameter of Bronchioles (constriction)



I'm Reading friend, don't need more Air!

Diameter of Bronchioles (dilation)

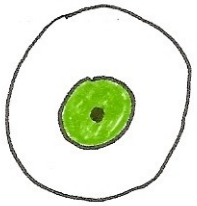


Now I have to Run, More Air Please!

What is the direct "effector tissue" for the bronchioles?

Remember, there are only **3** basic choices!

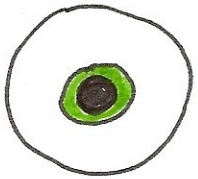
PARA Visio SYM n?



↓ Diameter of Pupil

(constriction)

"Near focus"

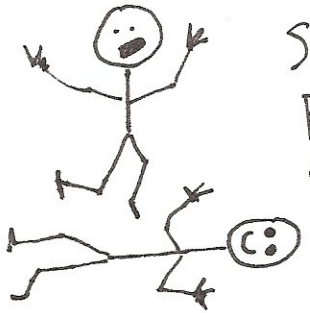


↑ Diameter of Pupil

(dilation)

"Distant Focus"

When I'm Calm & Relaxed, I enjoy Reading.



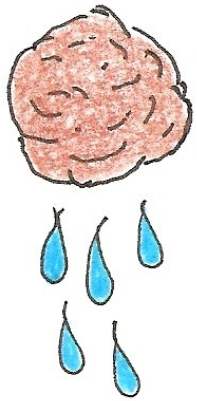
Stat, stat! Pupils Fixed and Dilated

Hmmm, coconut oil and butter are natural saturated fats with excellent medium chain fatty acids for human health. Good thing I read …

Note: Similar effects to Sympathetic stimulation are found from being in Love – seriously.

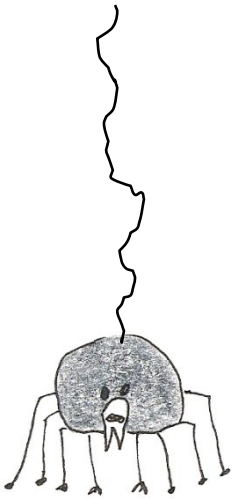
The pupil is a hole in the center of the iris (colored part) of the eye. It has two sets of intrinsic 'muscles' that can change pupil diameter, which changes the amount of light allowed in to hit the retina and photoreceptors.

PARA Saliv a & Swe at? SYM

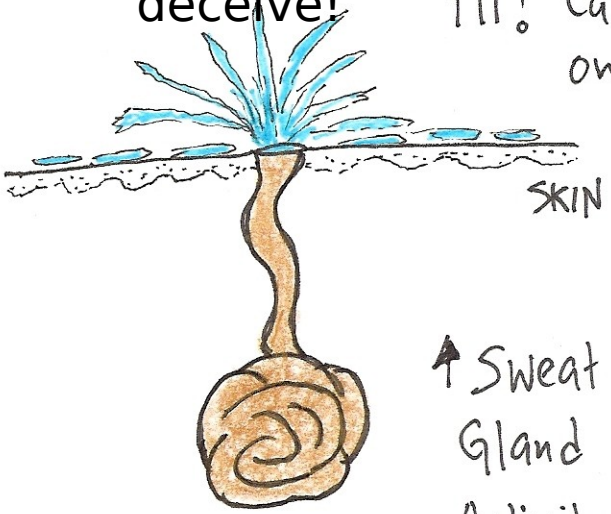


Watery
Salivary
Gland
Activity

"What a tangled web we weave, when our aim is to deceive!"



Hi! Can I crawl on you?



Sweat
Gland
Activity

Yum, I can just Imagine how nice this will taste!

Make sure it's Organic, **salvesterols** are

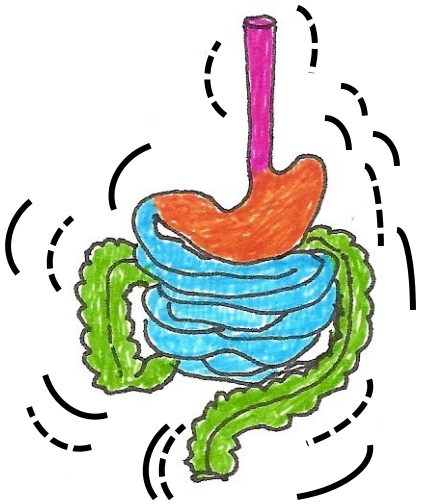
Note: Not telling the truth will also make you sweat!

PARA

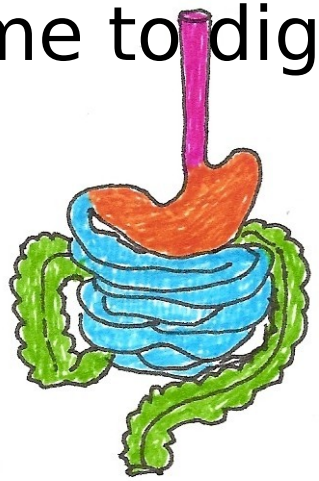
SYM

G.I. Tract Alimentary Canal?

Rest and **DIGEST**



Emergency - no time to digest!



In G. I. Tract Motility ↑

In G. I. Tract Secretions ↑

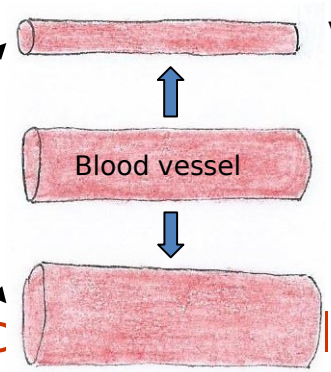
In G. I. Tract Motility ↓

In G. I. Tract Secretions ↓

More ANS Notes:

Vascular Smooth Muscle (**VSM**) is around blood vessel walls and is predominantly controlled by the **Sym** division of ANS, causing **vasoconstriction** and **vasodilation**.

Blood Vessel Diameter
Controls Blood Flow and Pressure



Vasoconstriction = increased BP

Vasodilation = decreased BP

Sympathetic postganglionic neurons release **norepinephrine** (NE) and:

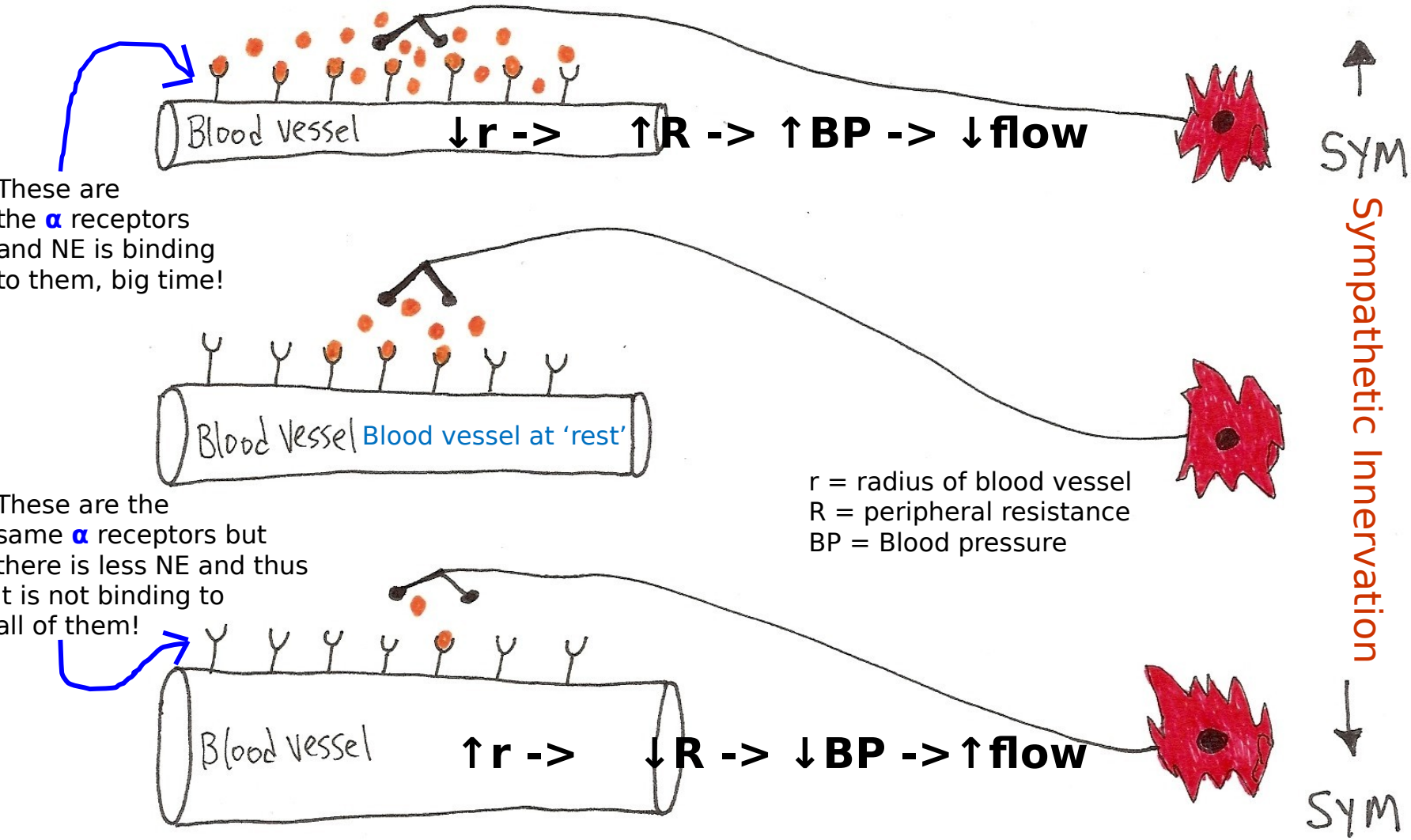
a) if α (alpha) receptors present = **vasoconstriction** = ↓Flow, ↑ Blood Pressure

b) if β (beta) receptors present = **vasodilation** = ↑Flow, ↓ Blood Pressure

The rule of thumb is: The more **Sym** stimulation there is, the more **constricted** blood vessels become (*except for blood vessels supplying skeletal muscle!*). This is why your blood pressure goes

od Vessel Diameter: Mostly controlled by the S

ally, *more* Sym innervation means *more* vessel constriction - if α's recep


Blood vessel
↓r -> ↑R -> ↑BP -> ↓flow
SYM
These are the α receptors and NE is binding to them, big time!
Blood vessel
Blood vessel at 'rest'
r = radius of blood vessel
R = peripheral resistance
BP = Blood pressure
Sympathetic Innervation
These are the same α receptors but there is less NE and thus it is not binding to all of them!
Blood vessel
↑r -> ↓R -> ↓BP -> ↑flow
SYM

α's = constriction; **β**'s = dilation. The vessel above must have which receptors? Alpha!

Skeletal muscle is controlled by the **Somatic** (soma = body) **nervous system** (SNS), it is **not** controlled by the Autonomic nervous system (ANS).

However, the SNS and the ANS do work together. The blood vessels supplying skeletal muscles have **β receptors** on them. When **sympathetic postganglionic** neurons release **norepinephrine** (**NE**), it binds to these β receptors, causing **vasodilation** of blood vessels supplying skeletal muscle – this results in an increase in blood flow to skeletal muscles - so you can run faster, swing your arms harder!

We will **not** go into details about neurotransmitters and receptors, but…
Makes sense, right?!

- At the ganglion, all preganglionic neurons release **ACh** on to **nicotinic** receptors.
- The postganglionic neurons for the **Para** division release **ACh** on to **muscarinic** receptors at the effector tissue. Effect is usually inhibitory.
- The postganglionic neurons for the **Sym** division release **NE** on to **alpha** or **beta** receptors at the effector tissue. Effect is usually excitatory.

erting Blood Flow is an important strate

In times of Emergency, this is what the **SYM** division does!!!

α R's =

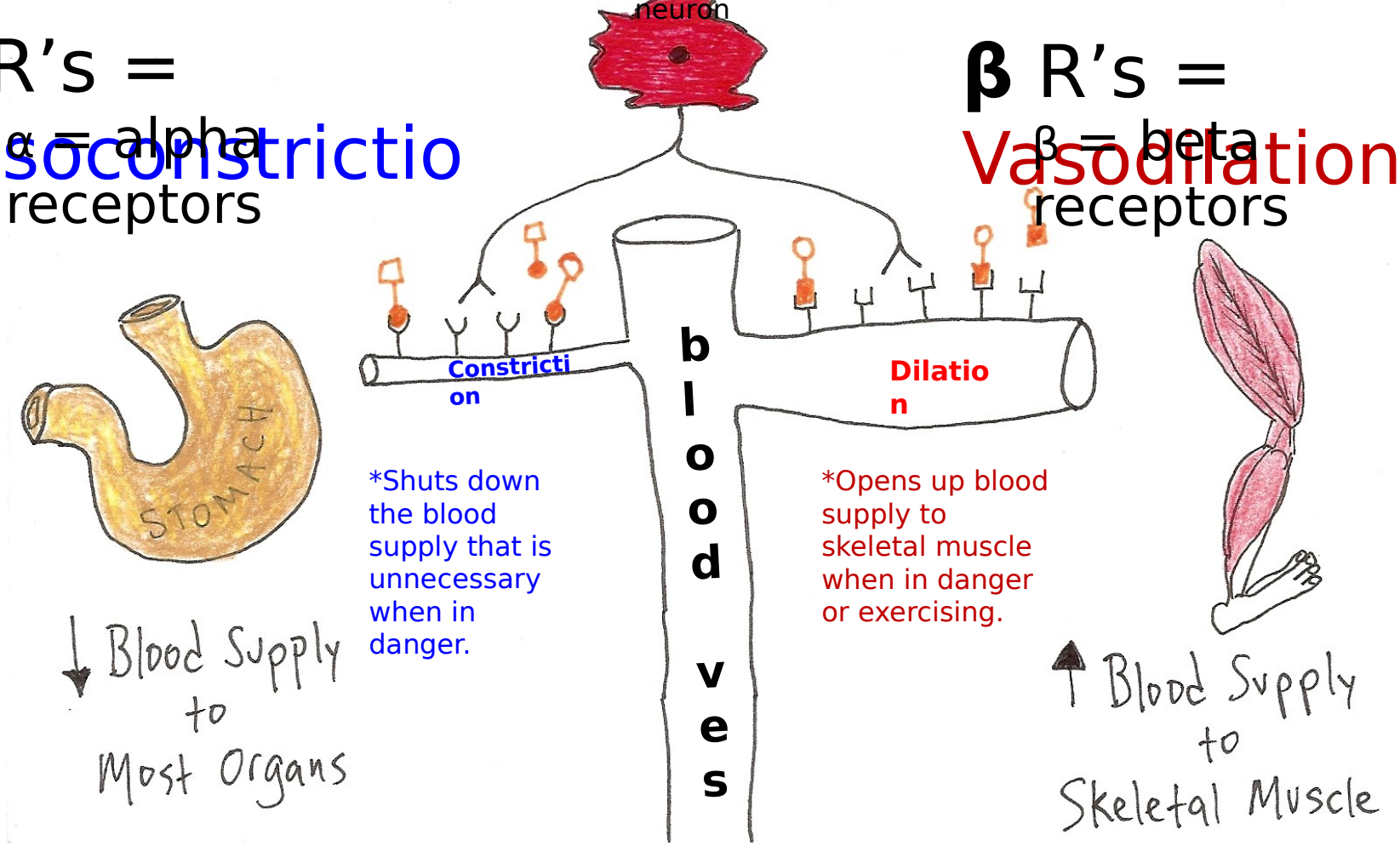
α = alpha receptors

Vasoconstrictio n*

β R's =

β = beta receptors

Vasodilation*


Sympathetic postganglionic neuron
Constricti on
Dilatio n
b l o o d v e s
STOMACH
↓ Blood Supply to Most Organs
*Shuts down the blood supply that is unnecessary when in danger.
*Opens up blood supply to skeletal muscle when in danger or exercising.
↑ Blood Supply to Skeletal Muscle

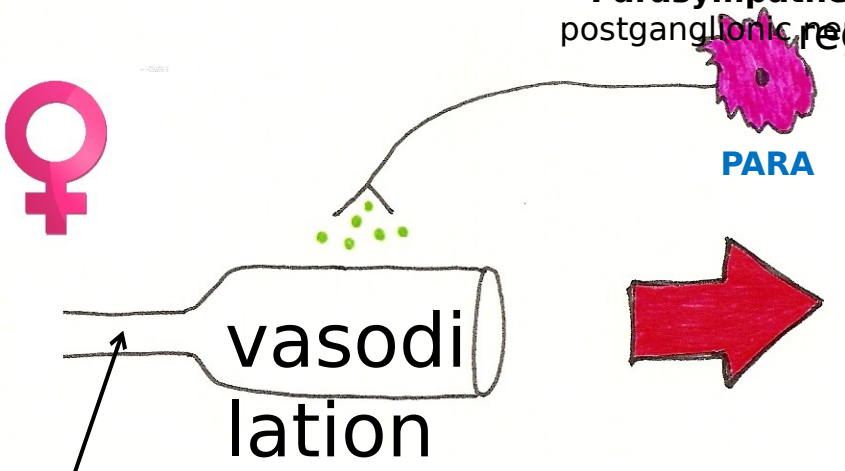
What's the Effector Tissue for blood vessels?

Note: The ANS does not innervate Skeletal Mus

PARASYMPATHETIC

*The PARA division has no effect on blood vessels or blood flow, **Except** to erectile tissue!

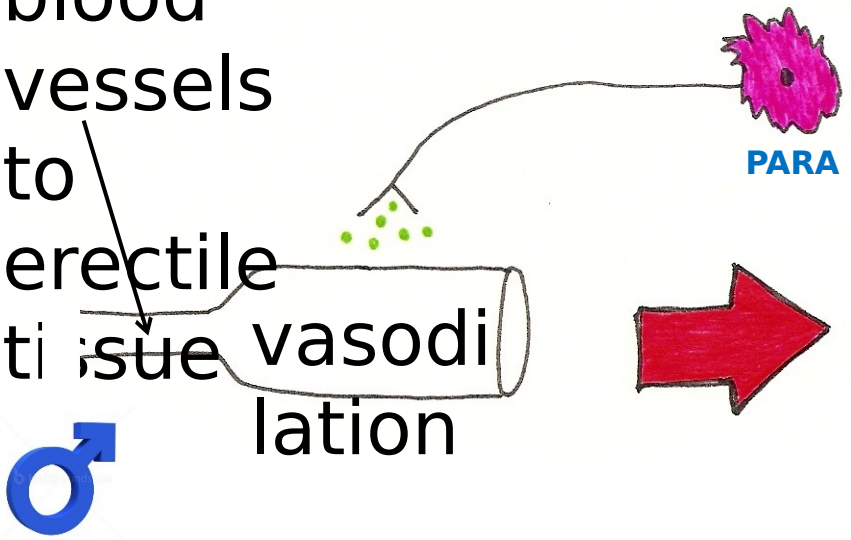
Here it causes **vasodilation**, which we know **increases** blood flow to a region.



Blood Flow to Erectile tissue of clitoris for females

blood vessels to erectile tissue

Yep –> Engorged and Tingly

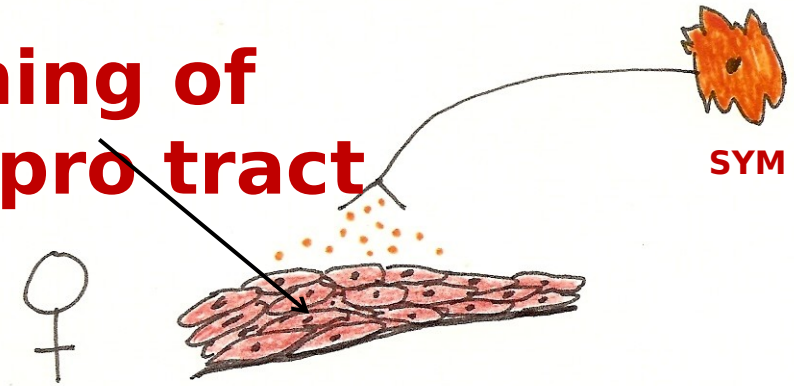


Blood Flow to Erectile tissue of penis for males

SYMPATHETIC

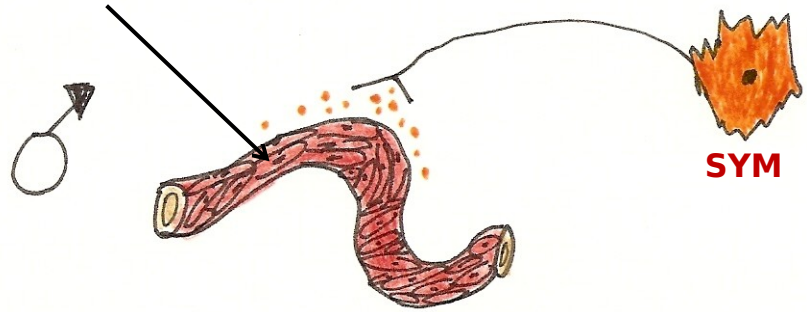
The SYM division acts on the **tracts** and **ducts** of the Reproductive System

Lining of Repro tract



Contraction of Reproductive Tract

ng of Repro duct



Yep –> Ejection of Fluids

Contraction of Reproductive Ducts

Q: What's the Effector Tissue that lines these ducts? Only have 3 basic choices!

Notes:

To Summarize, in matters of Reproduction…

Para relaxes VSM* and **increases** blood flow to erectile tissue = the "point" factor.

Sym causes the smooth muscle of reproductive ducts to **contract** = the "shoot" factor.

*VSM = vascular smooth muscle (the muscle around blood vessels)

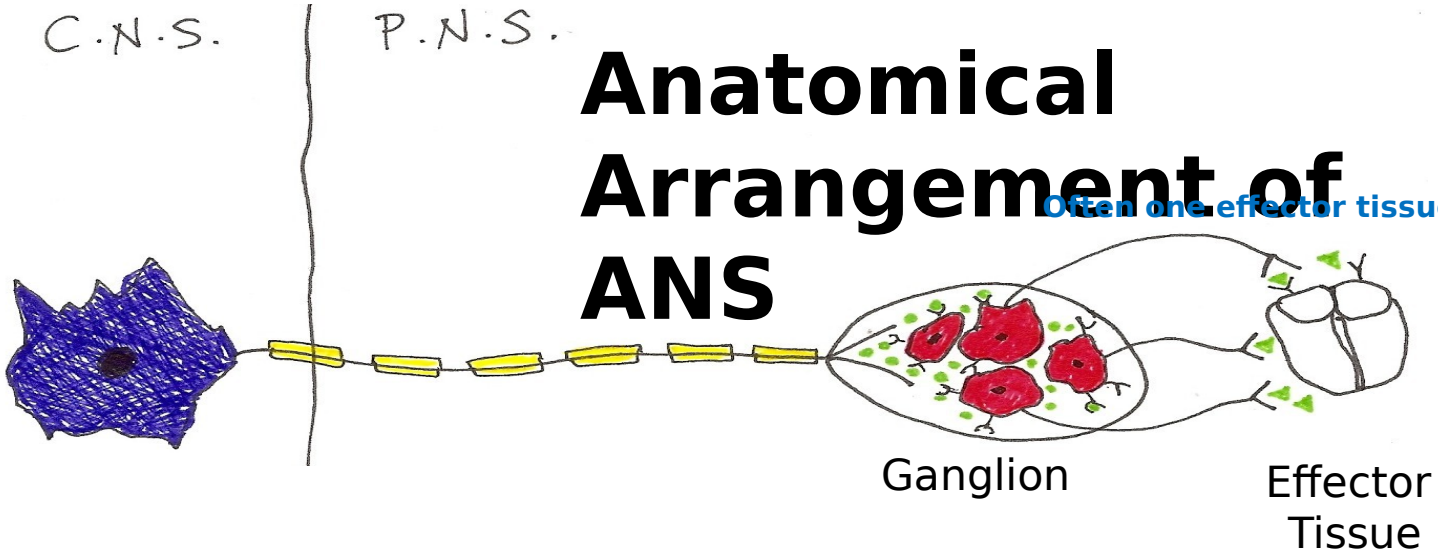
Lastly, the **Anatomical Arrangement** of two divisions is different and is indicative of their different actions.

- The **Para** division is more **Convergent**, such that it often focuses on **one thing at a time,** like only one effector tissue, not 4 at once. Usually, the **ganglion** for this division is very close to or *on* the effector tissue, so it is a *focused response*, it is not wide-spread.

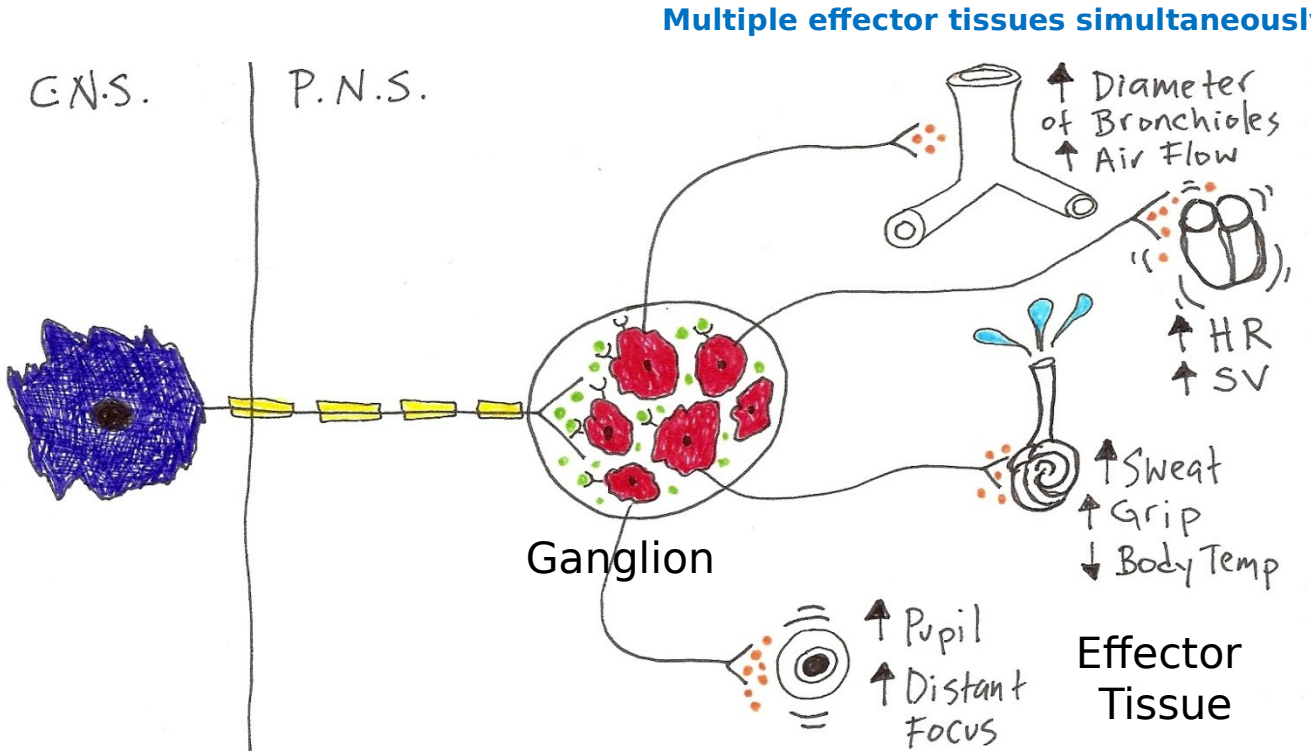
- The **Sym** division is more **Divergent**, such that it can **signal multiple tissues at once**. With **ganglion** for the Sym division so close to the spinal cord, this allows the response to be *wide-spread*, branching out into many different directions at the same time (simultaneously).

Examine the drawing on the next slide illustrating this!

Anatomical Arrangement of ANS



Para is CONVERGENT



Sym is DIVERGENT

ble of Actions of the 2 Divisions of the Autonomic Nervous Syste

Effector Tissue	Parasympathetic	Sympathetic
Iris (Eye Muscles)	Pupil Constriction (near focus)	Pupil Dilation (far focus)
Lacrimal Gland	Increases secretions (tears)	----------
Sweat Glands	----------	Increases secretions (sweat)
Lung Bronchioles	Bronchial constriction (decreased air flow)	Bronchial dilation (increased air flow)
Heart	Decreases Heart Rate Decreases Force of Beat	Increases Heart Rate - **β** Increases Force of beat – **β**
Blood Vessels of the Body	----------	Vasoconstriction - α Vasodilation - β
Salivary Glands	Increases Watery Saliva	Reduces Watery Saliva
G. I. Tract Activity	Increases Motility Increases Secretions	Decreases Motility Decreases Secretions
Liver	Glycogen synthesis (increases Glucose Liver storage)	Glycogen breakdown (releases Glucose into Blood)
Bladder Wall	Contraction (for voiding urine)	----------
Adrenal Medulla	----------	Epinephrine secreted into blood as a hormone
Erectile Tissue	Increases blood flow (vasodilation of blood vessels)	----------
Reproductive Tract	----------	Stimulation of contraction (ejection of fluids)

---------- means no effect